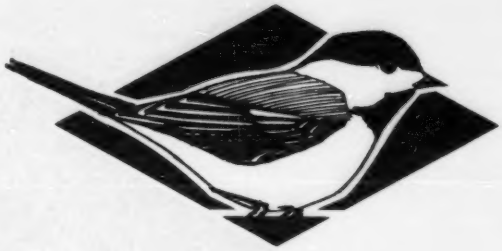

Fisheries & Wildlife Management Division

RESOURCE STATUS AND ASSESSMENT BRANCH

Status of the Bay-breasted Warbler (Dendroica castanea) in Alberta

Michael Norton

Alberta Wildlife Status Report No. 32

Alberta Conservation Association

Alberta

Status of the Bay-breasted Warbler (Dendroica castanea) in Alberta

Michael Norton

Alberta Wildlife Status Report No. 32

March 2001

Published By:

Alberta
ENVIRONMENT

Alberta Conservation
Association

Publication No. T/595
ISBN: 0-7785-1466-8
ISSN: 1206-4912

Series Editor: Isabelle M. G. Michaud
Senior Editor: David R. C. Prescott
Illustrations: Brian Huffman

For copies of this report, contact:
Information Centre - Publications
Alberta Environment
Natural Resources Service
Main Floor, Great West Life Building
9920 - 108 Street
Edmonton, Alberta, Canada T5K 2M4

Telephone: (780) 422-2079

OR

Information Service
Alberta Environment
#100, 3115 - 12 Street NE
Calgary, Alberta, Canada T2E 7J2

Telephone: (780) 297-3362

Visit our web site at :
http://www.gov.ab.ca/env/fw/status/reports/index.html

This publication may be cited as:

Norton, M.R. 2001. Status of Bay-breasted Warbler (Dendroica castanea) in Alberta. Alberta Environment, Fisheries and Wildlife Management Division, and Alberta Conservation Association, Wildlife Status Report No. 32, Edmonton, AB. 21 pp.

PREFACE

Every five years, the Fisheries and Wildlife Management Division of Alberta Natural Resources Service reviews the status of wildlife species in Alberta. These overviews, which have been conducted in 1991 and 1996, assign individual species to 'colour' lists that reflect the perceived level of risk to populations that occur in the province. Such designations are determined from extensive consultations with professional and amateur biologists, and from a variety of readily available sources of population data. A primary objective of these reviews is to identify species that may be considered for more detailed status determinations.

The Alberta Wildlife Status Report Series is an extension of the 1996 *Status of Alberta Wildlife* review process, and provides comprehensive current summaries of the biological status of selected wildlife species in Alberta. Priority is given to species that are potentially at risk in the province (Red or Blue listed), that are of uncertain status (Status Undetermined), or which are considered to be at risk at a national level by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

Reports in this series are published and distributed by the Alberta Conservation Association and the Fisheries and Wildlife Management Division of Alberta Environmental Protection, and are intended to provide detailed and up-to-date information which will be useful to resource professionals for managing populations of species and their habitats in the province. The reports are also designed to provide current information which will assist the Alberta Endangered Species Conservation Committee to identify species that may be formally designated as endangered or threatened under the Alberta Wildlife Act. To achieve these goals, the reports have been authored and/or reviewed by individuals with unique local expertise in the biology and management of each species.

EXECUTIVE SUMMARY

The Bay-breasted Warbler (Dendroica castanea) is currently included on the 'Blue List' of species that may be at risk in Alberta, due to concerns over habitat loss and declines in populations in some areas. This review summarizes available information on the Bay-breasted Warbler, as a step towards updating the status of this species in the province.

Bay-breasted Warblers are neotropical migrants that breed in the Boreal Forest and Foothills Natural Regions of Alberta. They require mature to old forest stands with a predominantly coniferous (usually spruce) canopy. Mixedwood stands of white spruce and trembling aspen or balsam poplar are typical of this species' habitat in Alberta. Bay-breasted Warbler populations are known to respond dramatically to spruce budworm outbreaks.

The principal concern over the status of the Bay-breasted Warbler relates to loss and degradation of its breeding habitat caused predominantly by the activities of the forestry and energy sectors. Silvicultural practices and government policy currently promote harvesting of older stands, and an "unmixing" of mixed-wood stands. Exploration and development for oil and gas further contributes to habitat loss and dissects large areas of forest with extensive linear disturbances. Projections are for rates of resource extraction activities to increase. Canadian populations of the Bay-breasted Warbler may have declined over the past 30 years, and recent evidence suggests that numbers will decline in disturbed areas. Habitat loss in wintering areas in Mexico, central America, and the Caribbean will likely exacerbate this situation.

The Bay-breasted Warbler is a relatively uncommon songbird across much of Alberta's 'Green Zone', and little detailed information exists as to its overall distribution, abundance, or habitat requirements. Available evidence suggests resource extraction activities may threaten this species' habitat. However, robust, longer-term data sets and a better understanding of the habitat requirements of the Bay-breasted Warbler will be needed to more adequately assess the status of the species in Alberta and to monitor effects of resource extraction.

ACKNOWLEDGEMENTS

Many thanks to those individuals who generously provided unpublished data and comments on the species, and answered many questions. These individuals are listed alphabetically: Barb Beck (University of Alberta); Mark Bradley (Parks Canada); Dr. Susan Hannon (University of Alberta); Bruce Harrison (University of Alberta); Ralph Jamieson (Alberta Environment); Richard Klauke; Craig Machtans (Environment Canda); Daryl Price (Alberta Environment); Sunil Ranasinghe (Alberta Environment); Dr. Fiona Schmiegelow (University of Alberta); Dr. Brad Stelfox (Forem Consulting); Lisa Takats (Alberta Conservation Association), Ken Wright (Alberta Conservation Association). Thanks are also due to: Theresa Morcos, Cindy McCallum, Matt Wheatley (University of Alberta), Jim Schieck (Alberta Research Council), Richard Chabaylo (Alberta Environment), Rick Lauzon and Peter Balagus (Axys Environmental Consulting), Ron Bennett (Canadian Wildlife Service), Peter Sherrington, Richard Thomas, and Pat Marklevitz. Steve Bennett (Mirkwood Ecological Consultants) kindly provided an unpublished manuscript. Brian Collins (Environment Canada) provided assistance on the interpretation of population trend analyses. Thanks to Mike Underschultz (Alberta Environment) for supplying digital information on spruce budworm. This report benefitted from reviews by Doug Collister, Susan Hannon and Carl Savignac.

Preparation of this report was funded by the Wildlife Management Enhancement Program of the Alberta Conservation Association.

101-05464/

TABLE OF CONTENTS

PREFACE iii

EXECUTIVE SUMMARY iv

ACKNOWLEDGEMENTS v

INTRODUCTION 1

HABITAT 1

CONSERVATION BIOLOGY 1

DISTRIBUTION 2

1. Alberta 2
2. Other Areas 4

POPULATION SIZE AND TREND 4

1. Alberta 6
2. Other Areas 6

LIMITING FACTORS 7

1. Habitat Loss and Fragmentation 7
2. Agriculture 8
3. Forest Management 8
4. Energy Sector Activities 9
5. Spruce Budworm 9
6. Nest Predation and Parasitism 10
7. Winter and Migration Stopover Habitat 10

STATUS DESIGNATIONS 11

1. Alberta 11
2. Other Areas 11

RECENT MANAGEMENT IN ALBERTA 11

SYNTHESIS 11

LITERATURE CITED 13

APPENDIX 1. 20

INTRODUCTION

The Bay-breasted Warbler (Dendroica castanea) is a neotropical migrant songbird in the family Parulidae (the wood warblers). This species breeds across the boreal forests of Canada and in the northeastern United States and winters in Panama and northern South America. The Bay-breasted Warbler is uncommon in most areas of Alberta and consequently little is known about its ecology. Recently, concerns over the degradation and loss of its breeding habitat through forest harvesting have led to the species' inclusion on the 'Blue List*' of species that may be at risk in Alberta (Alberta Wildlife Management Division 1996).

This report summarizes available information on the Bay-breasted Warbler, with an emphasis on breeding populations in Alberta in an effort to update its status in the province.

HABITAT

The available information on habitat preferences of the Bay-breasted Warbler emphasizes an association with coniferous tree species in mature or old forests (Erskine 1977, Godfrey 1986, Williams 1996). However, unpublished data from Alberta suggest the species may also use predominantly deciduous forests to some degree. In Alberta the Bay-breasted Warbler is known from the Boreal Forest and Foothills Natural Regions (Central, Wetland, and Dry Mixedwood and Lower Foothills Subregions; Achuff 1994).

There are very few published studies that have provided detailed descriptions of habitats occupied by the Bay-breasted Warbler. The few available reports consistently identify a strong association with coniferous tree species, usually spruce (Picea spp.) or fir (Abies spp.), and usually in mature forest stands (Erskine 1977, Morse 1978, Titterington et al. 1979, Enns and Siddle 1996, Bennett et al. 1999). Most reports also place the species in both pure coniferous stands as well as mixed coniferous-deciduous stands; they may be more abundant in mixed forest plots (Morse 1978), and in older stands (Welsh 1987). During the breeding season, Bay-breasted Warblers are almost never reported from disturbed sites and are usually classified as a forest specialist species.

In Alberta, the highest numbers of Bay-breasted Warblers have been associated with mature-old stands dominated by white spruce (Picea glauca), sometimes mixed with trembling aspen (Populus tremuloides), balsam poplar (Populus balsamifera) or white birch (Betula papyrifera). Aspen-dominated stands are also used, but apparently to a much lesser extent. Analysis of a large data set from a study near Calling Lake has shown Bay-breasted Warblers to respond positively to the amount of older forest within 400 m, and negatively to the amount of black spruce (Picea mariana) and deciduous-dominated forest (F. Schmiegelow, pers. comm.). A similar result has been reported from Maine (Hagan et al. 1997) where Bay-breasted Warblers responded positively to the total area of older forest within 1 km. However, the low frequency at which this species is encountered in Alberta has prevented most researchers from performing detailed habitat analyses.

CONSERVATION BIOLOGY

The Bay-breasted Warbler is a small, secretive wood warbler. Males and females of this species are fairly large compared to other members of the genus Dendroica: roughly 14 cm long and weighing about 13 g (Williams 1996); males are more brightly coloured. Very

* See Appendix 1 for definitions of selected status designations

little data exist on longevity, but the oldest bird on record was a minimum of 3 yr, 5 mo based on a band return (Klimkiewicz and Futcher 1989). No subspecies have been described, but Bay-breasted Warblers may hybridize on rare occasions with the closely related Blackpoll Warbler (Dendroica striata; Williams 1996).

The Bay-breasted Warbler is almost entirely insectivorous during the breeding season, but may switch to fruit on its winter range. Diet items in the summer are primarily lepidopteran (butterfly and moth) larvae and a variety of other small insects including beetles, flies, ants, grasshoppers and dragonflies (Griscom and Sprunt 1957, MacArthur 1958). The Bay-breasted Warbler is known to be a major predator of spruce budworm (Choristoneura fumiferana) and forest tent caterpillar (Malacosoma disstria) during outbreaks of these insects (Morse 1978, Sealy 1979). During the dry season on the winter range, the diet of the Bay-breasted Warbler may consist of >60% fruit (Morse 1989). Most foraging is diurnal, primarily by gleaning insects off leaves or needles near the trunk of trees, most typically at mid-level (MacArthur 1958).

The first Bay-breasted Warblers arrive in Alberta from mid to late May (Pinel et al. 1993). Pair formation presumably occurs shortly after arrival on the breeding grounds, and males aggressively attack and chase each other in territorial defense (Morse 1978). Little information exists as to territory size, but in general is likely similar to that of other wood warblers (0.25 ha to 1.0 ha); Sabo (1980) gives an estimate of 1.5 ha in New Hampshire. Nests are most often built in coniferous trees, on a lateral branch away from the main trunk at heights of 0.5 – 15 m (Bent 1953, MacArthur 1958, Peck and James 1987, Williams 1996). Only four nests have been reported in Alberta. Jones (1966) documented a nest high up in a white spruce. During the summer of 2000, three additional nests were found near Lesser Slave Lake Provincial Park (C. Savignac, pers. comm.). All three nests were in white spruce 24 cm to 53 cm in diameter and were 9 m to 12 m up. Almost no data has been collected on the breeding phenology of Bay-breasted Warblers, but again the pattern is likely similar to that of other wood warblers. Five or six eggs are laid, and are incubated by the female alone for 12 to 13 days (Bent 1953, Harrison 1975). Fledging dates of the three nests found in 2000 were estimated between 5 July and 15 July (C. Savignac, pers. comm.). Larger clutches may be laid during periods of high food supply (MacArthur 1958). Fledglings probably depart the nest after 10 or 11 days.

Fall migration in Alberta commences in mid August and runs through mid September; early and late dates are reported as 11 August and 29 September, respectively (Pinel et al. 1993). Bay-breasted Warblers are only rarely observed during migration in Alberta (Salt 1973), thus little is known about the patterns or routes followed. Annual survivorship is not known.

DISTRIBUTION

The high-pitched, weak song of the Bay-breasted Warbler is difficult for some observers to hear, and is easily confused with other more common songbird species. This, combined with its habit of remaining in mid to upper levels of the forest canopy, make the species difficult to census. Records from some areas of its range, including Alberta, are therefore sparse.

1. Alberta. - The Bay-breasted Warbler breeds in the forested portion of Alberta (the "Green" zone) outside of the Rocky Mountains (Figure 1), although several variants of its range have been published. The broadest range map published is that of Godfrey (1986) who

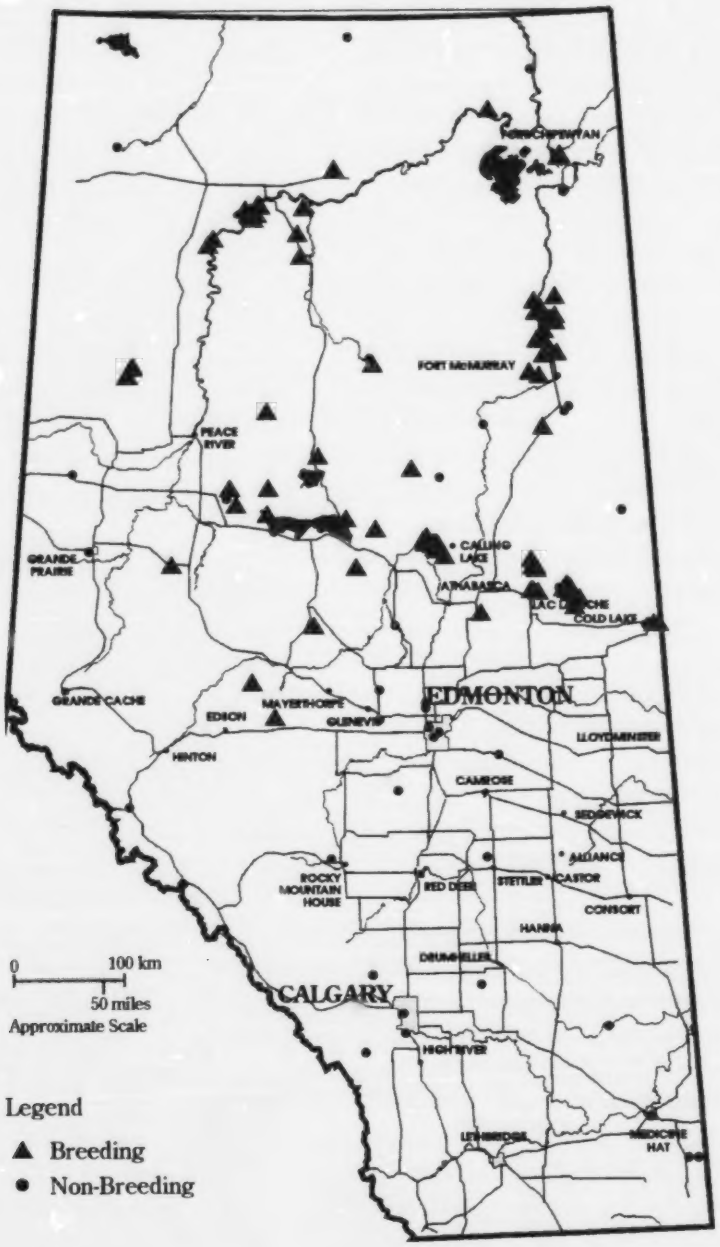

Figure 1. Bay-breasted Warbler observations in Alberta from 1908-1999. Breeding records are observations of confirmed breeding activity, or records of singing males from late May or June. Non-breeding records are observations of migrating birds, or other records for which no breeding information was available. Details of these records can be found within the Biodiversity/Species Observation Database maintained by Alberta Environment.

includes all of Alberta north of roughly 54°. The most restricted map includes only north-central and east-central portions of the province (McGillivray and Semenchuk 1998). The ranges depicted in Salt (1973) and Salt and Salt (1976) are intermediate to these, and exclude the northwest portion of the province. The most recent extensive survey effort (Semenchuk 1992) detected the species too rarely to confirm its range in Alberta.

The northern limit of the Bay-breasted Warbler in Alberta is documented in Wood Buffalo National Park (Preble 1908, Soper 1942, M. Bradley, pers. comm.). The species is known from several areas in north-central and east-central Alberta, including the areas around Utikuma Lake (Erskine 1968), Peerless Lake (Smith 1975), Calling Lake, Lac La Biche and Cold Lake (Salt 1973, Pinel et al. 1993). The most westerly records are from La Crete (L. Takats, pers. comm), Winagami Lake and Sturgeon Lake (Soper 1949, Pinel et al. 1993). The southern limit of the species' breeding range is probably roughly coincident with the limits of the Boreal Forest Natural Region and Lower Foothills Natural Subregion. There is a single, probable nesting record of the species in the McLeod River valley (Salt 1973) which lies in the Boreal Foothills Ecoregion. Bay-breasted Warblers are considered very rare visitors to Banff and Jasper National Parks (Holroyd and Van Tighem 1983).

Bay-breasted Warblers are also known from northeastern British Columbia (see below), suggesting that they may also breed in adjacent areas of northwestern Alberta. No documented breeding season records exist for this area however, and only a single migrant bird has been recorded, at Habay northwest of High Level (K. Wright, pers. comm.).

Bay-breasted Warblers probably do not breed in the Canadian Shield Natural Region in northeastern Alberta (Wallis and Wershler 1984, Erickson and McGillivray 1990), nor in the foothills east of Banff and Jasper National Parks. The species has also not been documented in the Swan Hills area (B. Beck, pers. comm., R. Klauke, pers. comm.).

2. Other areas. - Bay-breasted Warblers are close to their northern and western range limits in Alberta, but the species is well documented in both the Northwest Territories (Sirois and McRae 1996) and British Columbia (Cooper et al. 1997). They are relatively common in the Slave River valley (M. Bradley, pers. comm.) and around Fort Liard (C. Machtans, pers. comm.), both in the Northwest Territories. The species is also known from the Fort St. John and Fort Nelson areas of northeastern British Columbia (Cooper et al. 1997). From this northwestern limit of their range, Bay-breasted Warblers breed across Canada east to southwestern Newfoundland, and south into the U.S.A. to northern Minnesota, northern New York and Maine (Godfrey 1986; Figure 2). Local distributions can be strongly influenced by outbreaks of spruce budworm (MacArthur 1958, Morse 1978) or spruce budworm (Sealy 1979).

The Bay-breasted Warbler winters primarily in Central America and northern South America, including Costa Rica, Panama, Columbia, and Venezuela, with casual records from coastal California, Georgia and Florida (American Ornithologists' Union 1998). Higher numbers of vagrant individuals have been recorded in years with high budworm populations on breeding grounds (Pattern and Burger 1998).

POPULATION SIZE AND TRENDS

Difficulties in censusing Bay-breasted Warblers also affect estimations of population size and trends (see 'Distribution' section,

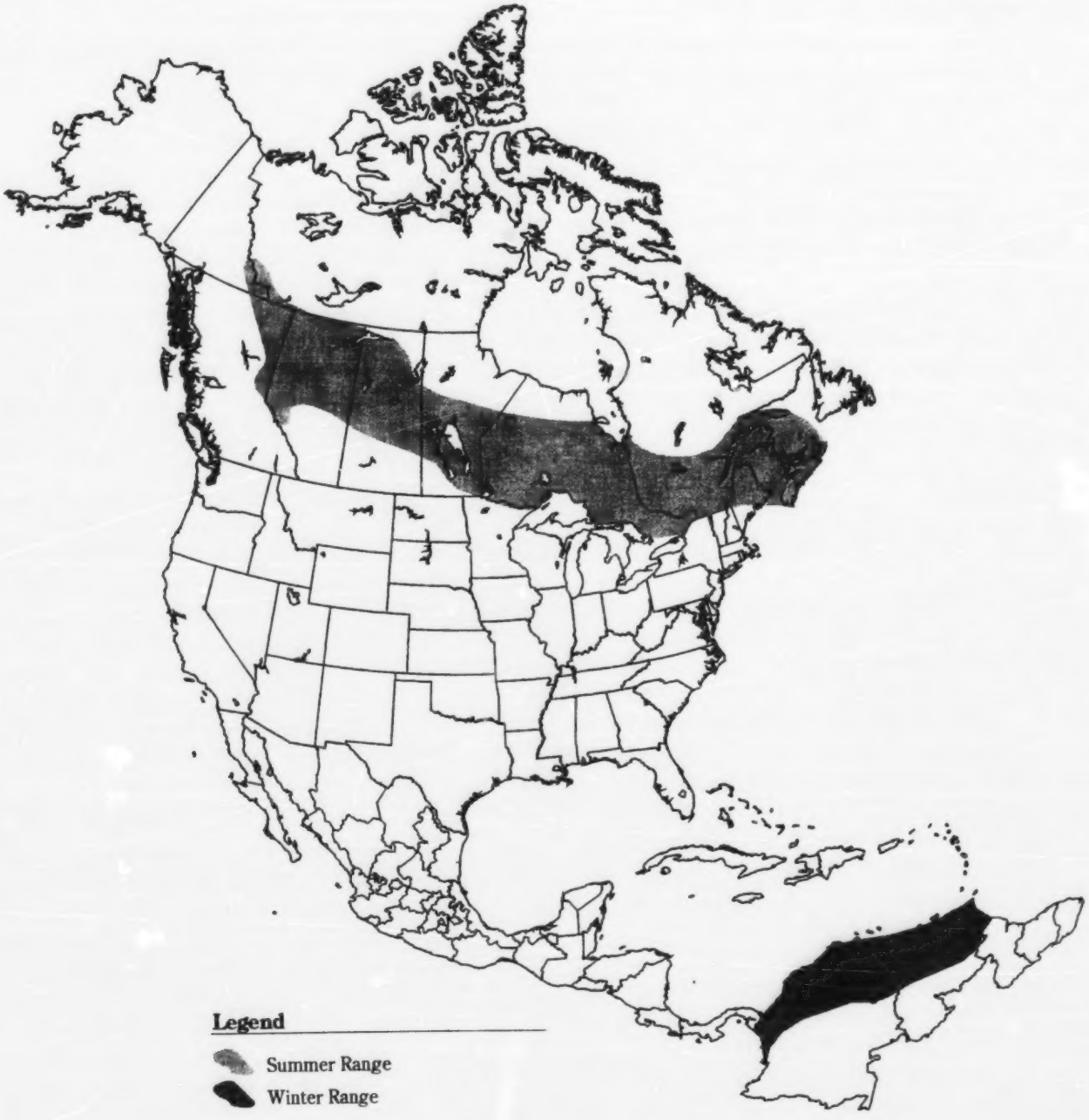

Figure 2. Summer and winter distribution of the Bay-breasted Warbler.

above). Further, any estimation of population size or trends in the future will be complicated by the species' strong numerical response to outbreaks of forest insects such as spruce budworm. In Ontario, Bay-breasted Warbler density doubled over a period of only four years in response to a budworm outbreak (Welsh 1985).

1. Alberta. - There are no estimates of the population size of Bay-breasted Warblers in Alberta. The species is usually described as uncommon and locally distributed. In most areas it is only rarely encountered, with most observers reporting only a very few records. The Atlas of Breeding Birds of Alberta project detected Bay-breasted Warblers in only 1.5% of squares (100 km^2 each) in the Boreal Forest Natural Region. There are a few areas, however, where it is apparently relatively abundant.

It is difficult to assess the overall abundance of Bay-breasted Warblers, or population trends, in Alberta. Systematic surveys have only been conducted in the southeastern portion of the boreal forest in Alberta, and at two other sites near Peace River and Fort Vermilion. Little or no survey work has been conducted in other areas, particularly areas north and west of the Peace River.

In certain habitats, Bay-breasted Warblers rank near the middle compared to other wood warblers in terms of abundance. They were the fifth most abundant of nine warbler species and the fifth of 19 detected at two studies near Calling Lake (Norton 1997, Norton et al. 2000, F. Schmiegelow, pers.comm.). Near Lac La Biche, Bay-breasted Warblers were the fifth most abundant of 18 warbler species (Wallis et al. 1994); they were 13th of 16 near Peace River (B. Harrison, pers. comm.). The highest abundances reported in Alberta are from the Fort Vermilion area, the only location in Alberta where singing males were close enough to be audible simultaneously (L. Takats, pers. comm.). High numbers were also suggested by Smith (Smith 1975) who encountered 25 in one day in late May or June north of Lesser Slave Lake. More often, however, the species is detected only in very low numbers (e.g., total of five detections at 403 census stations north of Lac La Biche; S. Hannon, pers. comm.). However, it is difficult to determine if these low reported numbers are an artifact of the habitats being sampled. Many of the large studies in Alberta have or are focussed on deciduous-dominated forests, and may therefore be under-representing the abundance of Bay-breasted Warblers.

There are no data which allow estimation of a population trend for Bay-breasted Warblers in Alberta. This species has only ever been reported from four Breeding Bird Survey routes in the province, and no research studies have sufficient temporal data for trend estimation over smaller areas.

2. Other areas. - There are also no estimates of the population size of Bay-breasted Warblers from other areas of its breeding range. Reported population densities from eastern North America range from 0.02 pairs/ha in areas with no spruce budworm (Erskine 1977), to 1.5 to 4 pairs/ha in local areas with severe budworm infestations (Erskine 1977, Morse 1978, Erskine 1992). In northeastern British Columbia, Bay-breasted Warblers were the third to fifth most abundant songbird in some mature riparian forests, at densities of roughly 0.2 to 1.0 pairs/ha with low budworm populations (Bennett et al. 1999). In Saskatchewan and Manitoba, densities of 0.01 to 0.9 pairs/ha and 0.01 to 0.13 pairs/ha, respectively, have been reported (Kirk et al. 1997). Although the numbers are difficult to compare directly, these numbers (BC, SK, MB) are likely comparable to densities of Bay-breasted Warblers in Alberta in preferred habitats.

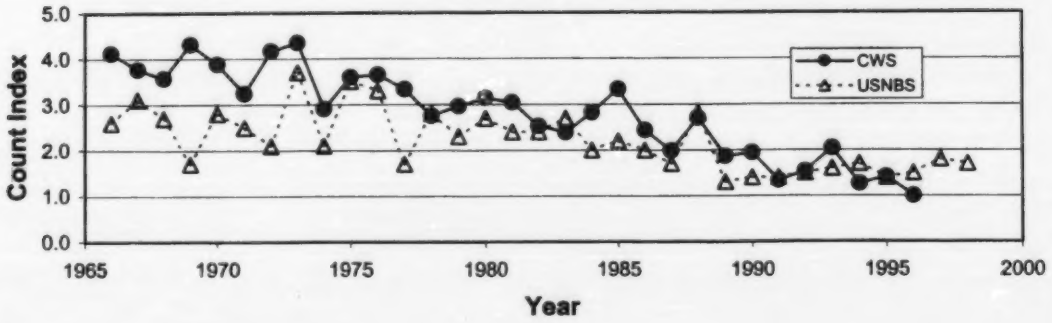

Figure 3. Annual indices for Bay-breasted Warbler in Canada derived from BBS data. Indices calculated by both Canadian Wildlife Service (CWS) and by the U.S. National Biological Survey (USNBS) are shown as analytic methods differ.

Population trend estimates for Bay-breasted Warblers may be derived from Breeding Bird Survey (BBS) data. The survey-wide and Canada-wide analyses show significant declines from 1980 to 1998 at –7.0% and –7.2% per year, respectively (Sauer et al. 1999). Longer-term analyses suggest a decline of between –2.0% per year (1966-1996; Sauer et al. 1997) and +0.5% year (1967-1998; Downes et al. 1999). These long-term trends are not statistically significant and the results should be viewed with caution due to the low number of birds detected on most routes and the small number of routes located within the breeding range of the Bay-breasted Warbler. The trends are represented in the annual indices for Bay-breasted Warbler (Figure 3). Note that different analytical methods are used by the Canadian and American partners in the BBS program; neither method is clearly better than the other so results from both are presented here.

LIMITING FACTORS

There is considerable debate in the scientific literature as to the relative significance of events occurring on breeding, wintering, and migratory stopover habitats, in terms of their effects on songbird populations (e.g., Bohning-Gaese et al. 1993, Rappole and McDonald 1994). For the purposes of this report, this section will mainly deal with events occurring in Alberta, within the breeding range of the Bay-breasted Warbler.

1. Habitat Loss and Fragmentation. - The loss and fragmentation of forest habitat are closely allied processes. 'Habitat loss' refers to the conversion of suitable habitat into unsuitable habitat, while 'fragmentation' is the increasing isolation and division of remaining habitat. Habitat fragmentation has been implicated in the declines of neotropical migratory songbird populations across North America (Robbins et al. 1989, Terborgh 1989). As the area of patches of suitable habitat declines, and the distances between those patches increases, the likelihood of individual patches supporting a subpopulation of birds declines (Saunders et al. 1991,Villard et al. 1995). Some species of songbirds have also been shown to be reluctant to cross habitat openings (Desrochers and Hannon 1997). Much of our understanding of the effects of forest fragmentation on birds developed from studies in agricultural landscapes in eastern

North America, but recent research in Alberta is showing less severe results (e.g., Schmiegelow and Hannon 1993). In an area of Quebec, Bay-breasted Warblers were shown to be absent from human-modified (clearcut) forested landscapes with <55% forest cover (Drolet et al. 1999). Other researchers have found insufficient numbers of Bay-breasted Warblers to draw any specific conclusions regarding this species' response to forest fragmentation, but it may be reasonable to assume that Bay-breasted Warblers will respond to habitat fragmentation in a similar fashion as other neotropical migrants.

These factors together (habitat loss, fragmentation, and edge avoidance) may lower bird reproductive success in fragmented forests by influencing pairing success (Gibbs and Faaborg 1990, Villard et al. 1993) or other factors (see 'Nest Predation and Parasitism', below). However, no specific studies have been conducted on Bay-breasted Warblers in relation to these factors. Habitat corridors may facilitate bird dispersal in a fragmented landscape, but there is likely to be a critical threshold in the degree of landscape fragmentation beyond which populations may decline more rapidly (With and Crist 1995). Overall, it is thought that the effects of habitat loss outweigh the effects of habitat fragmentation (Fahrig 1997). Thus, although the two processes are clearly linked, conservation efforts are probably best directed at slowing the rate of direct habitat loss.

2. Agriculture. - Agricultural expansion may be implicated as one possible cause of habitat loss and fragmentation. In the Alberta portion of the breeding range of the Bay-breasted Warbler, agriculture is largely limited to parts of the Peace River drainage (Northern Dry Mixedwood) and Athabasca River drainage (Southern Dry Mixedwood). In the Peace Country, 20 852 km^2 (~46%) of the land was in agricultural production in 1986, an increase of nearly 9000 km^2 since 1961 (Government of Canada 1991). A similar trend occurred in the Southern Dry Mixedwood between 1949 and 1950 and 1994 and 1995, when roughly 9000 km^2 of land were modified, for a total of 26 300 km^2 (~58%) of anthropogenically modified lands in the region (Alberta Environmental Protection 1998). It has been suggested, however, that agricultural expansion in the Peace River drainage is nearing its limits, as all economically viable land is already in use (MacLock et al. 1996).

3. Forest Management. - Timber harvesting has increased significantly in Alberta in recent years. Until relatively recently, most harvesting by the forestry sector was focussed on coniferous stands, but as of the mid-1980s, deciduous and mixedwood forests have also come under pressure. Large forested areas have been allocated to forest companies under Forest Management Agreements (FMAs). As of December 1995, there were 11 FMA holders in Alberta covering more than 13.6 million ha of the province's forested area (Alberta Environmental Protection 1996); by November 1998 this had increased to 17 FMA holders covering roughly 19.6 million hectares (D. Price, pers. comm.). These figures represent 60% and 87% allocation of the province's forested landbase, respectively. The proportion of the Annual Allowable Cut (AAC) allocated has also steadily increased. As of January 1995, roughly 85% of the province's AAC of timber had been allocated (94% coniferous, 73% deciduous), and the provincial government anticipates further increases in allocation and harvesting (Alberta Environmental Protection 1996). Between 1990 and 1996, approximately 58 000 ha of forest were harvested annually (Natural Resources Canada 1998), representing roughly 1% of the commercially productive landbase.

Bay-breasted Warbler habitat will likely be reduced in quantity and quality under the current forest harvesting strategies. Current operating ground rules for forestry in the province dictate a two- or three-pass clearcutting system, with the oldest stands prioritized for harvest (Alberta Environmental Protection 1994). Furthermore, with rotation lengths of 60 to 80 years, stands will be harvested just as they are becoming potentially suitable for Bay-breasted Warblers (see 'Habitat' section, above). Overall, current forest harvesting strategies will lead to a reduction in the proportion of old stands in the landscape, and will fragment previously contiguous forest.

Two current government policies in Alberta favour the elimination of mixedwood stands (Cumming et al. 1994) - a preferred habitat of the Bay-breasted Warbler. First, after mixedwood stands are harvested, they are typically reforested to pure coniferous or deciduous species following predetermined regeneration standards. Secondly, harvesting of deciduous-dominated stands every 60 to 80 years (Alberta Environmental Protection 1994) prevents these stands from reaching an age at which spruce trees reach the canopy (Lee et al. 1995). Both these policies contribute to the phenomenon of 'unmixing of the mixedwood', at the cost of suitable Bay-breasted Warbler habitat. Management of mixed stands may change in the future, however, with an increasing recognition of their value and a better understanding of management options (Peterson and Peterson 1992).

Increasingly, consideration is being given to modified harvest strategies, involving the retention of vegetation structure for wildlife habitat as an alternative to clearcutting. Trials involving appropriate Bay-breasted Warbler habitat have not been conducted. However, other forest specialist species were largely excluded from sites with vegetation retention rates up to roughly 40% (Norton and Hannon 1997, Schieck et al. 2000).

*4. **Energy Sector Activities**.* - Oil and gas development in the forested region of Alberta impacts the landscape through the clearing of forest for seismic exploration lines, pipelines, wellheads, and roads. Good statistics on energy sector activities are difficult to obtain. A crude estimate of the impact to date is roughly 9080 km^2 (3%) of cleared land in the Boreal Forest Natural Region (not including Wood Buffalo National Park; Alberta Environmental Protection 1998). Currently, roughly 14 000 km of new seismic lines are cut each year, and an additional 20 000 km of existing lines are re-cleared annually (R. Jamieson, pers. comm.). At an average width of 6 m, this translates to approximately 8400 ha of new forest cutting annually, and 12 000 ha of forest being re-opened. One estimate of linear disturbance density is 2 km/km^2 on the forest landbase in north-central Alberta (B. Stelfox, pers. comm.). The total area directly affected annually by energy sector activities may be comparable to that affected by the forest industry; on the Alberta-Pacific FMA area roughly 10 000 ha to 13000 ha are affected by the energy sector compared to roughly 16 000 ha by forestry (B. Stelfox, pers. comm.). However, due to the linear nature of many of these disturbances, the total area of forest that may feel the influence of these disturbances may be significantly higher. This adds to the impacts of forestry in causing habitat loss, and further reduces the availability of forest undisturbed by human activities, as well as creating semi-permanent open corridors into forested landscapes (see below).

*5. **Spruce Budworm.*** - The distribution, frequency, and severity of spruce budworm outbreaks may influence Bay-breasted Warbler distribution and abundance. In 1998, 114 668

ha of forest, (excluding the area north of Fort Chipewyan for which data were not available), were defoliated by budworm in Alberta, a large increase over the 50 056 ha defoliated in 1997 (Ranasinghe et al. 1998). Spraying of biological insecticides for spruce budworm began in 1989 in Alberta and has been effective in reducing budworm populations from epidemic to endemic levels (S. Ranasinghe, pers. comm.). In 1997 and 1998, spraying of a biological control agent was undertaken over 20 068 ha and 8801 ha, respectively, in areas north and west of High Level. In 2000, Alberta Environment did not conduct any aerial spraying to control spruce budworm infestations in the 'Green Area' (S. Ranasinghe, pers. comm.). This is because survey data in 1999 indicated low levels of budworm populations in previously infested areas of the province (S. Ranasinghe, pers. comm.). Alberta Environment is currently assessing the spruce budworm population levels expected in 2001 to determine whether spraying will be required (Ranasinghe, pers. comm.). If spraying is effective at controlling budworm outbreaks, it is possible that the increase in warbler numbers could be reduced (i.e. a smaller increase). Given the relatively few areas of the province that appear to have a problem with budworm, and a lack of information about the warblers in those areas (with or without a budworm outbreak), there is no conclusion to be made other than there being no cause for concern currently. The situation might be very different in the east where budworm outbreaks are more widespread, and warbler densities are higher to start with.

Alberta's current spraying policy includes the following guidelines: (1) Alberta Environment will only use federally registered biological insecticides for aerial spraying; (2)Aerial spraying of insecticides will be used, in conjunction with prioritized harvesting, as a part of an integrated approach to control spruce budworm infestations in the province; (3) Need for aerial spraying will be decided depending on the management objectives for a given Forest Management Unit (FMU) infested with spruce budworm and the level of spruce budworm control achievable by prioritized harvesting in that FMU; (4) Forest stands for aerial spraying within a given FMU will be selected based on the guidelines given in the "Spruce Budworm Management Guide" (S. Ranasinghe, pers. comm.).

6. Nest Predation and Parasitism. - In the heavily fragmented landscapes of eastern North America, where agriculture is the dominant land use, predation and parasitism of nests is thought to be a significant limiting factor of songbird populations (Andrén 1992, Donovan et al. 1995, Robinson et al. 1995). The Brown-headed Cowbird (Molthrus ater) regularly parasitizes nests of neotropical migrant songbirds, and predation of eggs by corvids can be significant. Bay-breasted Warblers are thought to be only rare hosts for cowbirds, because the two species' ranges rarely overlap (Williams 1996). However, species such as the Brown-headed Cowbird may gain access to forested landscapes via linear corridors, such as resource extraction roads, pipeline corridors, and seismic lines (Askins 1994). Edge habitats, which may facilitate predation or parasitism, are short-lived adjacent to cutblocks, but are longer-term features associated with linear disturbances and agricultural land clearing. Rates of nest predation and cowbird parasitism may be higher in areas of agricultural clearing than in areas affected by forestry (Bayne and Hobson 1997).

7. Winter and Migration Stopover Habitat. - Winter habitat degradation is likely a significant factor affecting songbird populations (Sherry and Holmes 1993) and may, in fact, be more significant than factors

on the breeding grounds (Rappole and McDonald 1994). Forest habitats in the wintering range of most North American songbirds are being depleted at an alarming rate: forest loss in Central America has been estimated at 2% annually (Hartshorn 1992). Bay-breasted Warblers are thus being affected by habitat alterations on both their summer and winter ranges.

STATUS DESIGNATIONS

1. Alberta. - The Bay-breasted Warbler is included on the 'Blue List' of species that may be at risk in the province (Alberta Wildlife Management Division 1996). This designation was made based on concerns over anticipated population declines in some areas coupled with expected loss of old growth habitats. The Alberta Natural Heritage Information Centre has assigned a provincial rank of S2S3, indicating uncertainty over its status, but concern due to its rarity (ANHIC 2001; see Appendix 1 for explanation of ranks).

In a federal conservation and management priority-setting exercise, the Bay-breasted Warbler was ranked first out of 232 landbird species in Alberta in terms of "provincial supervisory responsibility" (Dunn 1997). This ranking reflects both the species' extensive geographic range in the province combined with potential threats to its persistence.

2. Other Areas. - The Bay-breasted Warbler has not been considered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). The Global Heritage Status Rank for the Bay-breasted Warbler is G5 or 'demonstrably secure' throughout its range (Nature Serve 2000). In the United States, its Natural Heritage Status Rank is N5 (Nature Serve 2000). In British Columbia, the Bay-breasted Warbler is ranked S2 or 'imperiled' and is on the 'Red List' of vulnerable or sensitive species (Cooper et al. 1997, British Columbia Conservation Data Centre 2001). The Bay-breasted Warbler's restricted distribution and threats to its habitat (similar to those in Alberta) were cited as reasons for the recommended status in British Columbia. In Saskatchewan, the Bay-breasted Warbler is ranked as S4, or 'apparently secure' (Saskatchewan Conservation Data Centre 2001), S3 in Newfoundland and S1 in Labrador (Nature Serve 2000). Its rank in other Canadian jurisdictions and the state of Maine is either S4 or S5. It is ranked S1 in Vermont and S2 in New York, and states at the southeastern edge of this species' range.

RECENT MANAGEMENT IN ALBERTA

No specific management activities have been reported for this species in Alberta. However, several major research initiatives on forest management are underway in the province that include a songbird component (see Norton 1999 for a review). Most of these projects have been and continue to be focussed on deciduous-dominated habitats and therefore may not reveal much new insight into the Bay-breasted Warbler.

SYNTHESIS

Very little is known about the population size or trends of the Bay-breasted Warbler in Alberta. Data collected through Breeding Bird Surveys suggests the species may be declining in Canada. Available habitat descriptions suggest the species may be dependent on older, conifer-dominated forest stands that will decline in abundance and quality as a result of resource extraction. Larger scale surveys across the poorly known northern boreal zone, while expensive and logistically difficult would generate valuable basic information on the distribution and abundance of this and other

songbird species. Long-term, standardized studies will be crucial in determining the provincial trend of the Bay-breasted Warbler. A detailed characterization of the Bay-breasted Warbler's habitat use across all forest types used by the species could quantify features it requires (e.g., stand ages, tree species density and distribution). Since a reduction in the rate of forest harvest and clearing is unlikely in the near future, modifications to harvest practices and forest management policy should be pursued to guarantee the continued availability of suitable habitat.

LITERATURE CITED

ANHIC. 2001. Element Tracking Lists. Alberta Natural Heritage Information Centre. URL: http://www.gov.ab.ca/env/parks/anhic/anhic.html [Revision date: 6 July 2000].

Achuff, P. L. 1994. Natural regions, subregions and natural history themes of Alberta - a classification for protected areas management, revised and updated December 1994. Alberta Environmental Protection, Edmonton, AB. 114 pp.

Alberta Environmental Protection. 1994. Alberta timber harvest planning and operating ground rules. URL: http://www.gov.ab.ca/env/forests/fmd/grndrule/ground1.html [Accessed: 6 Jan. 2000].

Alberta Environmental Protection. 1996. The status of Alberta's timber supply. URL: http://www.gov.ab.ca/env/forests/fmd/timber/TimberSupply.html [Accessed: 11 Jan. 2000].

Alberta Environmental Protection. 1998. The Boreal Forest Natural Region of Alberta. Alberta Environmental Protection, Natural Resources Service, Edmonton, AB. 312 pp.

Alberta Fish and Wildlife. 1985. A policy for the management of threatened wildlife in Alberta. Alberta Fish and Wildlife, Edmonton, AB. 34 pp.

Alberta Fish and Wildlife. 1991. The Status of Alberta Wildlife. Alberta Forestry, Lands, and Wildlife, Wildlife Management Branch, Edmonton, AB. 49 pp.

Alberta Wildlife Management Division. 1996. The Status of Alberta Wildlife. Alberta Environmental Protection, Wildlife Management Division, Edmonton, AB. 44 pp.

American Ornithologists' Union (AOU). 1998. Check-list of North American birds. 7th edition. American Ornithologists' Union, Washington, DC. 829 pp.

Andrén, H. 1992. Corvid density and nest predation in relation to forest fragmentation: a landscape perspective. Ecology 73:794-804.

Askins, R. A. 1994. Open corridors in a heavily forested landscape: impact on shrubland and forest-interior birds. Wildl. Soc. Bull. 22:339-347.

British Columbia Conservation Data Centre. 2001. Tracking Lists. British Columbia Ministry of Environment, Lands and Parks. URL: http://www.elp.gov.bc.ca/rib/wis/cdc/ [Revision data: 10 November 2000]

Bayne, E. M., and K. A. Hobson. 1997. Comparing the effects of landscape fragmentation by forestry and agriculture on predation of artificial nests. Conserv. Biol. 11:1418-1429.

Bennett, S., P. P. Sherrington, P. Johnstone, and B. Harrison. 1999. Habitat use and distribution of listed neotropical migrant songbirds in northeastern British Columbia. Prepared for B.C. Ministry of Environment, Lands and Parks, Fort St. John, B.C. by Mirkwood Ecological Consultants, Ltd., Winlaw, BC. 38 pp.

Bent, A. C. 1953. Life histories of North American wood warblers. Smithsonian Institute Bulletin 203, Washington, DC. 734 pp.

Böhning-Gaese, K., M. L. Taper, and J. H. Brown. 1993. Are declines in North American insectivorous songbirds due to causes on the breeding range? Conserv. Biol. 7:76-86.

COSEWIC. 2001. Species at Risk in Canada. Committee on the Status of Endangered Wildlife in Canda. URL: http://www.cosewic.gc.ca [Last Updated: October 2000].

Cooper, J. M., K. A. Enns, and M. G. Shepard. 1997. Status of the Bay-breasted Warbler in British Columbia. B.C. Ministry of the Environment, Lands and Parks, Wildlife Working Report No. WR-79, Victoria, BC. 24 pp.

Cumming, S. G., P. J. Burton, S. Prahacs, and M. R. Garland. 1994. Potential conflicts between timber supply and habitat protection in the boreal mixedwood of Alberta: a simulation study. For. Ecol. Manage. 68:281-302.

Desrochers, A., and S. J. Hannon. 1997. Gap crossing decisions by forest songbirds during the post-fledging period. Conserv. Biol. 11:1204-1210.

Donovan, T. M., F. R. Thompson III, J. Faaborg, and J. R. Probst. 1995. Reproductive success of migratory birds in habitat sources and sinks. Conserv. Biol. 9:1380-1395.

Downes, C. M., B. T. Collins, and B. P. McBride. 1999. The Canadian Breeding Bird Survey 1966-1999. National Wildlife Research Centre, Canadian Wildlife Service, Hull, Quebec. URL: http://199.212.18.79/Birds/default.cfm [Revision date: 28 September 1999].

Drolet, B., A. Desrochers, and M.-J. Fortin. 1999. Effects of landscape structure on nesting songbird distribution in a harvested boreal forest. Condor 101:699-704.

Dunn, E. H. 1997. Setting priorities for conservation, research and monitoring of Canada's landbirds. Technical Report Series No. 293, Canadian Wildlife Service, Ottawa, ON. 107 pp.

Enns, K. A. and C. Siddle. 1996. The distribution, abundance, and habitat requirements of selected passerine birds of the boreal and taiga plains of British Columbia. Ministry of Environment, Lands and Parks, Wildlife Branch, Wildlife Working Report No. WR-76, Victoria, BC. 44 pp.

Erickson, G., and W. B. McGillivray. 1990. Birds of the Andrew Lake region. Pp. 83-91 in Natural history of the Andrew Lake region, northeastern Alberta. (W. B. McGillivray and R. I. Hastings, eds.). Provincial Museum of Alberta, Nat. Hist. Occ. Pap. No. 12, Edmonton, AB.

Erskine, A. J. 1968. Birds observed in north-central Alberta, summer 1964. Blue Jay 26:24-31.

Erskine, A. J. 1977. Birds in boreal Canada: communities, densities and

adaptations. Canadian Wildlife Service Report Series No. 41, Ottawa, ON. 73 pp.

Erskine, A. J. 1992. Atlas of breeding birds of the maritime provinces. Nova Scotia Museum, Halifax, NS. 270 pp.

Fahrig, L. 1997. Relative effects of habitat loss and fragmentation on population extinction. J. Wildl. Manage. 61:603-610.

Gibbs, J. P., and J. Faaborg. 1990. Estimating the viability of Ovenbird and Kentucky Warbler populations in forest fragments. Conserv. Biol. 4:193-196.

Godfrey, W. E. 1986. The birds of Canada. National Museum of Canada, Ottawa, ON. 595 pp.

Government of Canada. 1991. The state of Canada's environment – 1991. Environment Canada, State of the Environment Reporting, Ottawa, ON.

Griscom, L., and A. Sprunt Jr. 1957. The warblers of America. Devin-Adair Co., NY. 356 pp.

Hagan, J. M., P. S. McKinley, A. L. Meehan, and S. L. Grove. 1997. Diversity and abundance of landbirds in a northeastern industrial forest. J. Wildl. Manage. 61:718-735.

Harrison, H. H. 1975. A field guide to birds' nests of 285 species found breeding in the United States east of the Mississippi River. Houghton Mifflin, Boston, MA. 257 pp.

Hartshorn, G. S. 1992. Forest loss and future options in Central America. Pp. 13-19 in Ecology and conservation of neotropical migrant landbirds (J. M. Hagan III and D.W. Johnston, eds.). Smithsonian Institute Press, Washington, DC.

Holroyd, G., and K. Van Tighem. 1983. The ecological (biophysical) land classification of Banff and Jasper National Parks, Vol. 3, the wildlife inventory. Canadian Wildlife Service, Edmonton, AB. 691 pp.

Jones, E. A. 1966. A Bay-breasted Warbler nest record for Alberta. Blue Jay 24:140.

Kirk, D. A., A. W. Diamond, A. R. Smith, G. E. Holland, and P. Chytyk. 1997. Population changes in boreal forest birds in Saskatchewan and Manitoba. Wilson Bulletin 109:1-27.

Klimkiewicz, M. K., and A. G. Futcher. 1989. Longevity records of North American birds Supplement 1. J. Field Ornithol. 60:469-494.

Lee, P. C., S. Crites, and J. B. Stelfox. 1995. Changes in forest structure and floral composition in a chronosequence of aspen mixedwood stands in Alberta. Pp. 29-48 in Relationships between stand age, stand structure, and biodiversity in aspen mixedwood forests in Alberta (J. B. Stelfox, ed.). Alberta Environmental Centre (AECV95-R1), Vegreville, AB, and Canadian Forest Service (Project No. 0001A), Edmonton, AB.

MacArthur, R. H. 1958. Population ecology of some warblers of northeastern coniferous forests. Ecology 39:599-619.

MacLock, R. B., B. Lyons, and E. Ellehoj. 1996. Environmental overview of the northern river basins. Synthesis Report No. 8, Northern River Basins Study, Edmonton, AB. 124 pp.

McGillivray, W. B., and G. P. Semenchuk. 1998. Field guide to Alberta birds. Federation of Alberta Naturalists, Edmonton, AB. 350 pp.

Morse, D. H. 1978. Populations of Bay-breasted Warblers during an outbreak of the spruce budworm. Wilson Bull. 90:404-413.

Morse, D. H. 1989. American warblers: an ecological and behavioral perspective. Harvard University Press, Cambridge, MA. 406 pp.

National Research Council. 1995. Science and the Endangered Species Act. National Academy Press, Washington, DC. 271 pp.

Natural Resources Canada. 1998. National forestry database program. URL: http://nfdp.ccfm.org/frames2_e.htm [Accessed: 26 May 2000].

NatureServe: An online encyclopedia of life (web application). 2000. Version 1.2 . Arlington, Virginia, USA: Association for Biodiversity Information. URL: http://www.natureserve.org [Accessed: 23 February 2001].

Norton, M. R. 1997. From cutblock to landscape: site-specific and landscape-scale responses of songbirds to forest harvesting. M.Sc. thesis, University of Alberta, Edmonton, AB. 94 pp.

Norton, M. R. 1999. Status of the Black-throated Green Warbler (Dendroica virens) in Alberta. Alberta Environment, Fisheries and Wildlife Management Division, and Alberta Conservation Association, Wildlife Status Report No. 23, Edmonton, AB. 24 pp.

Norton, M. R. and S. J. Hannon. 1997. Songbird response to partial-cut logging in the boreal mixedwood forest of Alberta. Can. J. For. Res. 27:44-53.

Norton, M. R., S. J. Hannon, and F. K. A. Schmiegelow. 2000. Fragments are not islands: patch vs landscape perspectives on songbird presence and abundance in a harvested boreal forest. Ecography 23:209-223.

Pattern, M. A., and J. C. Burger. 1998. Spruce budworm outbreaks and the incidence of vagrancy in eastern North American wood-warblers. Can. J. Zool. 76:433-439.

Peck, G. K., and R. D. James. 1987. Breeding birds of Ontario: nidiology and distribution. Royal Ontario Museum, Toronto, ON. 321 pp.

Peterson, E. B., and N. M. Peterson. 1992. Ecology, management, and use of aspen and balsam poplar in the prairie provinces. Forestry Canada, Northwest Region, Northern Forestry Centre. Special Report 1, Edmonton, AB. 252 pp.

Pinel, H. W., W. W. Smith, and C. R. Wershler. 1993. Alberta birds, 1971-1980. Volume 2. Passerines. Provincial Museum of Alberta, Nat. Hist. Occ. Pap. No. 20, Edmonton, AB. 238 pp.

Preble, E. A. 1908. A biological investigation of the Athabasca – Mackenzie region. North American Fauna No. 27, Government Printing Office, Washington, DC. 574 pp.

Ranasinghe, S. K., C. Kominek, M. Maximuchuk, S. Schwartz, E. Lee, and E. Zidek. 1998. Forest health in Alberta. 1998 annual report. Forest Protection Division, Alberta Environmental Protection, Edmonton, AB. 42 pp.

Rappole, J. H., and M. V. McDonald. 1994. Cause and effect in population declines of migratory birds. Auk 111:652-660.

Robbins, C. S., J. R. Sauer, R. S. Greenberg, and S. Droege. 1989. Population declines in North American birds that migrate to the Neotropics. Proceedings of the National Academy of Science USA 86:7658-7662.

Robinson, S. K., F. R. Thompson III, T. M. Donovan, D. R. Whitehead, and J. Faaborg. 1995. Regional forest fragmentation and the nesting success of migratory birds. Science 267:1987-1989.

Sabo, S. R. 1980. Niche and habitat relations in sub-alpine bird communities of the White Mountains of New Hampshire. Ecological Monographs 50:241-259.

Salt, W. R. 1973. Alberta vireos and wood warblers. Provincial Museum and Archives of Alberta, Publication No. 3, Edmonton, AB. 141 pp.

Salt, W. R., and J. R. Salt. 1976. The birds of Alberta. Hurtig Publishers, Edmonton, AB. 498 pp.

Saskatchewan Conservation Data Centre. 2001. Vertebrate Species Lists. URL: http://www.biodiversity.sk.ca/FTP.htm [Access date: 1 March 2001].

Sauer, J. R., J. E. Hines, G. Gough, I. Thomas, and B. G. Peterjohn. 1997. The North American Breeding Bird Survey Results and Analysis. Version 96.4. Patuxent Wildlife Research Center, Laurel, MD. URL: http://www.mbr.nbs.gov/bbs/bbs96.html.

Sauer, J. R., Hines, J. E., Thomas, I., Fallon, J., and Gough, G. 1999. The North American Breeding Bird Survey, results and analysis 1966 - 1998. Version 98.1. USGS Patuxent Wildlife Research Centre, Laurel MD. URL: http://www.mbr.nbs.gov/bbs/bbs.html [Accessed: 2 May 2000].

Saunders, D. A., R. J. Hobbs, and C. R. Margules. 1991. Biological consequences of ecosystem fragmentation: a review. Conserv. Biol. 5:18-32.

Schieck, J., K. Stuart-Smith, and M. R. Norton. 2000. Bird communities are affected by amount and dispersion of vegetation retained in mixedwood boreal forest harvest areas. For. Ecol. Manage. 126:239-254.

Schmiegelow, F. K. A., and S. J. Hannon. 1993. Adaptive management, adaptive science and the effects of forest fragmentation on boreal birds in northern Alberta. Transactions of the North American Wildlife and Natural Resources Conference 58:584-598.

Sealy, S. C. 1979. Extralimital nesting of Bay-breasted Warblers: response to forest

tent caterpillars? Auk 96:600-603.

Semenchuk, G. P. (ed.) 1992. The atlas of breeding birds of Alberta. Federation of Alberta Naturalists, Edmonton, AB. 390 pp.

Sherry, T. W., and R. T. Holmes. 1993. Are populations of neotropical migrants limited in summer or winter? Implications for management. Pp. 47-57 in Status and management of neotropical migrants. (D. M. Finch and P. W. Stangel, eds.). U.S. Department of Agriculture Forest Service General Technical Report RM-229, Fort Collins, CO.

Sirois, J., and D. McRae. 1996. The birds of the Northwest Territories: a miniguide to a megaterritory and a checklist. 2nd ed. Canadian Wildlife Service, Yellowknife, NT. 28 pp.

Smith, H. C. 1975. The birds north of Lesser Slave Lake, Alberta. Blue Jay 33:232-239.

Soper, J. D. 1942. The birds of Wood Buffalo Park and vicinity, northern Alberta and district of Mackenzie, N.W.T., Canada. Transactions of the Royal Canadian Institute 19-97.

Soper, J. D. 1949. Birds observed in the Grande Prairie - Peace River region of northwestern Alberta, Canada. Auk 66:233-257.

Terborgh, J. 1989. Where have all the birds gone? Princeton University Press, Princeton, NJ. 207 pp.

Titterington, R.W. H.S. Crawford, and B.N. Burgason. 1979. Songbird responses to commercial clearcutting in Maine spruce-fir forests. J. Wildl. Manage. 43:602-609.

Villard, M.-A., P. R. Martin, and C. G. Drummond. 1993. Habitat fragmentation and pairing success in the Ovenbird (Seiurus aurocapillus). Auk 110:759-768.

Villard, M.-A., G. Merriam, and B. A. Maurer. 1995. Dynamics in subdivided populations of Neotropical migratory birds. Ecology 76:27-40.

Wallis, C. A., W. W. Smith, and C. R. Wershler. 1994. An overview of wetland, old-growth and riparian avian resources in Lakeland Provincial Park and Provincial Recreation Area. Prepared by Cottonwood Consultants Ltd. for Alberta Parks Services, Lac La Biche, AB. 122 pp.

Wallis, C. A., and C. R. Wershler. 1984. Kazan Upland resource assessment for ecological reserves planning in Alberta. Prepared by Cottonwood Consultants Ltd. for Alberta Energy and Natural Resources, Public Lands Division. ENR Report No. T/54 and Natural Areas Technical Report No. 12. 67 pp.

Welsh, D. A. 1985. Preliminary studies of the relationship between spruce budworm and birds in the boreal forest of Ontario. Pp.164-172 in Recent advances in spruce budworm research (C. J. Saunders, R. W. Stark, E. J. Mullins, and J. Murphy, eds.). Proceedings of the CANUSA Spruce Budworm Research Symposium, Bangor, ME.

Welsh, D. A. 1987. The influence of forest

harvesting on mixed coniferous-deciduous boreal bird communities in Ontario, Canada. Acta Oecologia 8:247-252.

Williams, J. M. 1996. Bay-breasted Warbler. No. 206. in The birds of North America (A. Poole and F. Gill, eds.). National Academy of Science, Philadelphia, PA, and American Ornithologists' Union, Washington, DC. 19 pp.

With, K. A., and T. O. Crist. 1995. Critical thresholds in species' responses to landscape structure. Ecology 76:2446-2459.

APPENDIX 1. Definitions of selected legal and protective designations.

A. Status of Alberta Wildlife colour lists (after Alberta Wildlife Management Division 1996)

Red	Current knowledge suggests that these species are at risk. These species have declined, or are in immediate danger of declining, to a nonviable population size.
Blue	Current knowledge suggests that these species may be at risk. These species have undergone non-cyclical declines in population or habitat, or reductions in provincial distribution.
Yellow	Species that are not currently at risk, but may require special management to address concerns related to naturally low populations, limited provincial distributions, or demographic/life history features that make them vulnerable to human-related changes in the environment.
Green	Species not considered to be at risk. Populations are stable and key habitats are generally secure.
Undetermined	Species not known to be at risk, but insufficient information is available to determine status.

B. Alberta Wildlife Act

Species designated as 'endangered' under the Alberta Wildlife Act include those defined as 'endangered' or 'threatened' by *A Policy for the Management of Threatened Wildlife in Alberta* (Alberta Fish and Wildlife 1985):

Endangered	A species whose present existence in Alberta is in danger of extinction within the next decade.
Threatened	A species that is likely to become endangered if the factors causing its vulnerability are not reversed.

C. Committee on the Status of Endangered Wildlife in Canada (after COSEWIC 2001)

Extinct	A wildlife species that no longer exists.
Extirpated	A wildlife species that no longer exists in the wild in Canada, but exists elsewhere in the wild.
Endangered	A wildlife species that is facing imminent extirpation or extinction.
Threatened	A wildlife species that is likely to become an endangered species if nothing is done to reverse the factors leading to its extirpation or extinction.
Special Concern (Vulnerable)	A wildlife species of special concern because it is particularly sensitive to human activities or natural events, but does not include an extirpated, endangered or threatened species.
Not at Risk	A wildlife species that has been evaluated and found to be not at risk.
Indeterminate	A species for which there is insufficient scientific information to support status designations.

D. United States Endangered Species Act (after National Research Council 1995)

Endangered	Any species which is in danger of extinction throughout all or a significant portion of its range.
Threatened	Any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

E. Heritage Status Ranks (after Nature Serve 2000)

G1/S1	**Critically Imperiled**: Critically imperiled globally because of extreme rarity or because of some factor(s) making it especially vulnerable to extinction. Typically 5 or fewer occurrences or very few remaining individuals (<1,000) or acres (<2,000) or linear miles (<10).
G2/S2	**Imperiled**: Imperiled globally because of rarity or because of some factor(s) making it very vulnerable to extinction or elimination. Typically 6 to 20 occurrences or few remaining individuals (1,000 to 3,000) or acres (2,000 to 10,000) or linear miles (10 to 50).
G3/S3	**Vulnerable**: Vulnerable globally either because very rare and local throughout its range, found only in a restricted range (even if abundant at some locations), or because of other factors making it vulnerable to extinction or elimination. Typically 21 to 100 occurrences or between 3,000 and 10,000 individuals.
G4/S4	**Apparently Secure**: Uncommon but not rare (although it may be rare in parts of its range, particularly on the periphery), and usually widespread. Apparently not vulnerable in most of its range, but possibly cause for long-term concern. Typically more than 100 occurrences and more than 10,000 individuals.
G5/S5	**Secure**: Common, widespread, and abundant (although it may be rare in parts of its range, particularly on the periphery). Not vulnerable in most of its range. Typically with considerably more than 100 occurrences and more than 10,000 individuals.
GX/SX	**Presumed Extirpated**—Element is believed to be extirpated from the nation or subnation*. Not located despite intensive searches of historical sites and other appropriate habitat, and virtually no likelihood that it will be rediscovered.
GH/SH	**Possibly Extirpated** (Historical)—Element occurred historically in the nation or subnation*, and there is some expectation that it may be rediscovered. Its presence may not have been verified in the past 20 years. An element would become NH or SH without such a 20-year delay if the only known occurrences in a nation or subnation were destroyed or if it had been extensively and unsuccessfully looked for. Upon verification of an extant occurrence, NH or SH-ranked elements would typically receive an N1 or S1 rank. The NH or SH rank should be reserved for elements for which some effort has been made to relocate occurrences, rather than simply using this rank for all elements not known from verified extant occurrences.

List of Titles in This Series
(as of March 2001)

No. 1 Status of the Piping Plover (Charadrius melodus) in Alberta, by David R. C. Prescott. 19 pp. (1997)

No. 2 Status of the Wolverine (Gulo gulo) in Alberta, by Stephen Petersen. 17 pp. (1997)

No. 3 Status of the Northern Long-eared Bat (Myotis septentrionalis) in Alberta, by M. Carolina Caceres and M. J. Pybus. 19 pp. (1997)

No. 4 Status of the Ord's Kangaroo Rat (Dipodomys ordii) in Alberta, by David L. Gummer. 16 pp. (1997)

No. 5 Status of the Eastern Short-horned Lizard (Phrynosoma douglassii brevirostre) in Alberta, by Janice D. James, Anthony P. Russell and G. Lawrence Powell. 20 pp. (1997)

No. 6 Status of the Prairie Rattlesnake (Crotalus viridis viridis) in Alberta, by Sheri M. Watson and Anthony P. Russell. 26 pp. (1997)

No. 7 Status of the Swift Fox (Vulpes velox) in Alberta, by Susan E. Cotterill. 17 pp. (1997)

No. 8 Status of the Peregrine Falcon (Falco peregrinus anatum) in Alberta, by Petra Rowell and David P. Stepnisky. 23 pp. (1997)

No. 9 Status of the Northern Leopard Frog (Rana pipiens) in Alberta, by Greg Wagner. 46 pp. (1997)

No. 10 Status of the Sprague's Pipit (Anthus spragueii) in Alberta, by David R. C. Prescott. 14 pp. (1997)

No. 11 Status of the Burrowing Owl (Speotyto cunicularia hypugaea) in Alberta, by Troy I. Wellicome. 21 pp. (1997)

No. 12 Status of the Canadian Toad (Bufo hemiophrys) in Alberta, by Ian M. Hamilton, Joann L. Skilnick, Howard Troughton, Anthony P. Russell, and G. Lawrence Powell. 30 pp. (1998)

No. 13 Status of the Sage Grouse (Centrocercus urophasianus urophasianus) in Alberta, by Cameron L. Aldridge. 23 pp. (1998)

No. 14 Status of the Great Plains Toad (Bufo cognatus) in Alberta, by Janice D. James. 26 pp. (1998)

No. 15 Status of the Plains Hognose Snake (Heterodon nasicus nasicus) in Alberta, by Jonathan Wright and Andrew Didiuk. 26 pp. (1998)

No. 16 Status of the Long-billed Curlew (Numenius americanus) in Alberta, by Dorothy P. Hill. 20 pp. (1998)

No. 17 Status of the Columbia Spotted Frog (Rana luteiventris) in Alberta, by Janice D. James. 21 pp. (1998)

No. 18 Status of the Ferruginous Hawk (Buteo regalis) in Alberta, by Josef K. Schmutz. 18 pp. (1999)

No. 19 Status of the Red-tailed Chipmunk (Tamias ruficaudus) in Alberta, by Ron Bennett. 15 pp. (1999)

No. 20 Status of the Northern Pygmy Owl (Glaucidium gnoma californicum) in Alberta, by Kevin C. Hannah. 20 pp. (1999)

No. 21 Status of the Western Blue Flag (Iris missouriensis) in Alberta, by Joyce Gould. 22 pp. (1999)

No. 22 Status of the Long-toed Salamander (Ambystoma macrodactylum) in Alberta, by Karen L. Graham and G. Lawrence Powell. 19 pp. (1999)

No. 23 Status of the Black-throated Green Warbler (Dendroica virens) in Alberta, by Michael R. Norton. 24 pp. (1999)

No. 24 Status of the Loggerhead Shrike (Lanius ludovicianus) in Alberta, by David R. C. Prescott and Ronald R. Bjorge. 28 pp. (1999)

No. 25 Status of the Plains Spadefoot (Spea bombifrons) in Alberta, by Richard D. Lauzon. 17 pp. (1999)

No. 26 Status of the Trumpeter Swan (Cygnus buccinator) in Alberta, by M. Lynne James. 21 pp. (2000)

No. 27 Status of the Pygmy Whitefish (Prosopium coulteri) in Alberta, by William C. Mackay. 16 pp. (2000)

No. 28 Status of the Short-eared Owl (Asio flammeus) in Alberta, by Kort M. Clayton. 15 pp. (2000)

No. 29 Status of the Willow Flycatcher (Empidonax traillii) in Alberta, by Bryan Kulba and W. Bruce McGillivray. 15 pp. (2001).

No. 30 Status of the Woodland Caribou (Rangifer tarandus caribou) in Alberta, by Elston Dzus. 47 pp. (2001)

No. 31 Status of the Western Spiderwort (Tradescantia occidentalis) in Alberta, by Bonnie Smith. 12 pp. (2001)

No. 32 Status of the Bay-breasted Warbler (Dendroica castanea) in Alberta, by Michael Norton. 21 pp. (2001)